

THE DESTRUCTION OF THE FRESH-WATER FAUNA IN WESTERN PENNSYLVANIA.

(PLATE VI.)

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It is generally known that the advance of civilization in a country is connected with a retreat and the disappearance of the indigenous fauna. This has been observed most distinctly in those parts of the world which have been settled by the white man in more recent times, and in many cases we have positive records with reference to the killing and crowding out of the original inhabitants of the country, belonging to the animal kingdom; yet these records chiefly concern the more highly developed forms of life (mammals or vertebrates in general), which preëminently attract attention.

But there are many other forms of animal life, chiefly among the invertebrates, which suffer the same fate. Such cases generally are not noticed, but students particularly interested in such groups often have reason to deplore the disappearance of interesting creatures, which used to be abundant.

The present writer, in connection with his duties as curator of invertebrate zoölogy at the Carnegie Museum, has made it one of his chief objects to study and to preserve records of the fresh-water fauna of the northeastern section of the United States, and first of all, of the country lying in the immediate vicinity of Pittsburgh. This region belongs to the drainage of the upper Ohio and of Lake Erie, and it is well known that originally a very rich fauna was present here, a fauna which forms part of the great fauna of the interior basin, eminently rich in all forms of fresh-water life. It is also a well-known fact that on account of the progress of civilization in western Pennsylvania, on account of its industrial and commercial development, and all the various features of "improve-

ments" connected with it, the fresh-water fauna has deteriorated, has become poor, and in many cases extinct. Yet it is not realized how far this process has advanced, and to what extent the fresh water of this region has become unfit for the indigenous life. The present paper has the object to record the present state of things in this respect, and to point out which rivers and creeks are in such a state that they do not offer any more the required conditions for animal life, and which are yet in a good or fair condition. It may be remarked that all facts collected here have been ascertained by the writer in person, in the course of his studies during the last five years. All streams recorded on the map accompanying this paper (Plate VI) have been visited by the writer, and collections of their invertebrate fauna and observations on their vertebrate fauna have been made, wherever such was still present: but in many cases his efforts were in vain, and life had entirely disappeared in many streams. The blue color on our map tells a pitiful story, pitiful not only from the standpoint of the scientific man, but also with reference to the question of utility. For we must not forget that the original fauna of the fresh water forms part of the "natural resources" of the country. In many cases the direct economic value, chiefly of the fresh-water invertebrates, is not very apparent; but considering the fact that all forms of life in an ecological community are mutually dependent upon each other, we realize that the more important forms (mussels, fishes and aquatic mammals) cannot be preserved, unless the creatures which furnish the necessary conditions for their subsistence are also preserved. Thus the destruction of our fresh-water fauna forms a chapter of the book on the destruction of our natural resources, a record which is not at all to the credit of the nation.

I. THE FRESH-WATER FAUNA.

The part of the fresh-water fauna which has chiefly been studied by the writer is, as has been stated, the *invertebrates*. However, during his investigations, he kept his eyes open for *vertebrate* life, and among the latter it is chiefly the *fishes* to which he paid attention. He did not make systematic collections of the fishes, and thus

he cannot give positive information as to the presence or absence of particular species of them. But the question of their existence in general in the different streams is easily settled, in fact this is the most conspicuous criterion by which people generally judge the condition of a stream—whether there is “good fishing” or not.

However, the presence of fishes in a stream does not always indicate that the latter is in good shape. The condition of the streams, as we shall see below, often changes during the season; it is bad in dry weather, but improves when there has been copious precipitation. The fishes are most apt to take advantage of such temporary improvement on account of their great power of locomotion (vagility); in fact, many fishes migrate more or less regularly up or down stream, and thus may be present at certain seasons in parts of our water-courses, which are barren in other seasons.

Other vertebrates are of minor importance. Among the mammals we should mention the muskrat (*Fiber zibethicus*). This animal is fairly abundant everywhere, but, as might be expected, tends to disappear, where its food disappears. The latter consists only in part of invertebrates (mussels for instance), while in another part it is vegetable (roots of aquatic plants, and also various parts of land plants). Thus it is understood that the pollution of a stream does not render the existence of muskrats impossible. And further, the bad condition of the water does not harm the animal directly, since it is an air-breathing form. The fact that the muskrat is decidedly less frequent in polluted streams is probably due to the fact that the pollution is greatest in the vicinity of larger settlements, where there is greater danger for them by being hunted by man.

Of the reptiles, water-snakes (*Natrix sipedon* and *leberis*) and turtles should be considered. As regards the former, it is a general rule that they disappear from polluted streams, and very likely not on account of the direct influence of the water upon their body, but on account of the destruction of their food—fish and crawfish. The turtles live in part upon animal, in part upon vegetable food; they are found, at present, in numbers only in streams which are in good condition, and have disappeared, more or less, in those with

polluted waters; this, however, at least in certain species, is apparently due also to direct extermination by man. The soft shell turtle (*Aspidoectes spinifer*) is a good example; it used to be present almost everywhere, but it has been exterminated practically in the Ohio, the lower Allegheny, the Monongahela and Youghiogheny. It is still present, for instance, in the clear waters of the upper Youghiogheny, the upper Allegheny, in Lake Erie, etc.

Among the amphibians, frogs and toads do not prefer the streams; they rather are pond and lake forms, and, besides, inhabit the water only at certain seasons. They do not seem to be very susceptible to the quality of the water, since they are air-breathing animals, and, consequently, are still abundant, although certain species show a tendency to become rare. Thus the bullfrog is met with in numbers only in the northwest of the state, where clear streams, ponds and lakes prevail. Yet in this case, extermination by man has surely played a part.

Of the Urodela, the smaller salamanders and newts do not inhabit in large numbers the rivers and creeks, but prefer rather the mountain streams, the ponds and lakes, where generally the conditions are yet good. Thus there does not seem to be an appreciable reduction of their number. The two large salamanders, the hellbender (*Cryptobranchus allegheniensis*) and mud puppy (*Necturus maculosus*) surely are influenced by the pollution, yet not directly, but by the destruction of their food. They seem to be the last members of the fresh-water fauna which disappear, and are occasionally found where there is no other permanent life. (Hellbenders were frequent in the Conemaugh River at New Florence, Westmoreland Co. Nothing but a few fish and crawfish were at this locality, which apparently came from a clear tributary.)

The most important forms of invertebrates, which I have studied more closely, are the crustaceans and the mollusks. Occasionally I have collected fresh-water sponges, worms, bryozoans, but of all these we may say that they disappear very soon after the stream has become polluted. They are found only in such waters which contain an abundance of other life.

The crustaceans of the genus *Cambarus* (crawfishes) are rather susceptible, and we may say that generally the pollution of a stream

destroys them. They seem to be slightly more resistant than the Unionidæ (see below), but their presence in a polluted stream is in many cases clearly due to a restocking of the stream, by immigration from a clear tributary. The crawfishes are rather vagile, and possess the power to migrate, although less so than the fishes. There surely is the possibility for them to take advantage of a temporary improvement of the condition of a stream.

The most important group, with reference to the matter in question, are the bivalve mollusks of the family Unionidæ, the fresh-water mussels or river-clams. They are the most reliable indicators of the pollution of a stream. Being rather sedentary, living on the bottom of the rivers, breathing water, they are easily influenced by the deterioration of the water. Of all the more important groups of our fresh-water fauna, they die first, and after they have been exterminated, it is exceedingly difficult to restock the stream on account of the complex life history of the young mussels. It is known that the young Unionidæ are transported and dispersed by fishes, but in a polluted stream the fishes have also disappeared, and even in a case of a temporary recovery of a stream, in times of a high stage of the water, if there should be a restocking with young mussel-fry, the latter will surely be killed during the next low stage, when the pollution again is concentrated. In this respect the Unionidæ surely are worse off than the fishes and crawfishes.

Of other mollusks, the gasteropods belonging to the family Pleuroceridæ (*Pleurocera*, *Goniobasis*, *Anculosa*) should be mentioned. They are generally absent in polluted rivers, but have been found surviving, together with crawfishes, in parts where Unionidæ were entirely, and the fishes for the greater part gone (Allegheny River in southern Venango County). Other mollusks, which are air breathing (genera *Lymnæa*, *Planorbis*, *Physa*) are more resistant, and this is especially true of *Physa*, which represents in certain instances the only remaining life in certain rivers. But there also seems to be a limit to its power of endurance, and in very badly polluted streams also *Physa* is absent.

Thus we can establish, in a rough way, a certain succession for the disappearance of our fauna.

The first sign of pollution of a dangerous character in a stream

is given by the disappearance of the Unionidæ, and, generally, this fauna is irreparably lost. Close upon this follows the disappearance of the fishes, yet in times of recovery of the rivers (at high-water stages), fishes reappear, coming from tributaries, etc., which have acted as preserves, and this may go on indefinitely as long as the river is recovering again at times, since the fishes possess a high power of locomotion (as we shall see below, the construction of dams in a river puts an end also to this). Crawfishes stand it a little longer than fishes, but they also disappear finally, and the temporary restocking of a stream takes place only in a limited degree.¹ With the crawfishes, or soon after them, the Gasteropods of the family *Pleuroceridæ* are driven out. When the process has reached this stage, the higher forms of life, which subsist on these various forms are compelled to abandon the stream: *tailed Batrachians*, *Snakes*, and part of the *Turtles*. Finally, only *Lynnæa*, *Planorbis* and *Physa*, and the muskrat survive. Of these, *Physa* disappears last, while the muskrat may stay indefinitely, being not entirely dependent upon animal or aquatic food.

II. THE CAUSES OF THE DESTRUCTION OF THE FAUNA.

A. *Direct Extermination by Man.*

A number of fresh-water animals are directly killed by man, and thus disappear in streams, the character of which has not been changed unfavorably for life. This is true in the first line for the *fishes*. Fishes, forming part of human food, are sought for everywhere, and in consequence of the increase of the population necessarily must be decimated in number. Yet a complete destruction of the fish life hardly has ever been brought about by man alone, chiefly so, if the fishing is carried on under the restrictions put upon it by law. The fact is that there are many places where "fishing is good," and where fishermen freely avail themselves of this chance, but where fishes are still abundant (upper Allegheny River, for

¹ It happens sometimes that restocking of the lost territory is done by a different species. Thus in the Mahoning Creek at Punxsutawney, Jefferson Co., and in Slipperyrock Creek at Branchton, Butler Co., the original species, which was destroyed, was *Cambarus obscurus*, and subsequently, *C. bartoni* entered the creek.

instance). This is not so in certain remote streams, but not on account of the legitimate pursuit of the sport, but in consequence of the illegal destruction of the fishes. The worst is the dynamiting of the streams which, of course, can be carried out safely only in such places where the fish warden is likely not watching. I can name at least one stream, in which this has had serious consequences: *Raccoon Creek* in Beaver County, and here it is done, as I have been informed, by parties that come over the state line from West Virginia and Ohio, and that have no right whatever to fish in our waters. The fish warden cannot be on the spot all the time, and the farmers of the region are powerless to stop the abuse, and thus *Raccoon Creek*, which is physically in good condition, and which used to teem with fish life, has been spoiled. For the dynamiting kills all fishes, old and young indiscriminately, and must be regarded as the most contemptuous way of wanton destruction.

I do not doubt that it is resorted to in other parts (I heard of one case in *Deer Creek*, Allegheny County, not far from Pittsburgh), yet, of course, since it is executed by the guilty parties only under rigorous precautions, in order that they may not be caught by the authorities, such cases generally escape detection.

There is only one other group of fresh-water animals which is of direct value to man (if we disregard the muskrat, which is hunted for its pelt, and some turtles, which are eaten). These are the fresh-water mussels (*Unionidæ*). For food they are not much sought, but the occasional occurrence of pearls in them makes them valuable. In Pennsylvania pearl fishing is not much practiced, yet I know that certain individuals hunt for pearls in mussels along the Allegheny River in Armstrong County, and once I came across a party of three, hunting pearls in the Ohio in Beaver County. These people were from somewhere down the Ohio in the state of Ohio or West Virginia, and it was indeed a sight to look upon the wholesale destruction carried on by them.

In general we may say that by the direct action of man our fresh-water fauna, chiefly that of the fishes, has suffered a good deal, but the complete extermination has not been brought about by it in any stream. Fishing might go on in the usual way, under the established legal restrictions, and our fish fauna will survive indefi-

nately. If we further consider the fact that the state is trying to restock our streams artificially, this might entirely counterbalance the losses caused by the fisherman, and thus we may say that fishing alone would never destroy our fish fauna.

B. *Pollution of Streams.*

The worst damage to our fauna is done by the *pollution* of the streams, that is to say, by the discharge into them of substances which are directly injurious to life. This is connected directly with our commercial and industrial progress, and the damage done by it is irreparable, unless there is some radical change in the way of the disposal of the industrial refuse, which at present is generally allowed to run directly into the nearest stream.

The most widely distributed pollution of a stream is by *sewage* from the larger towns and cities. This in itself is rather innocent. I am not discussing the deterioration of the waters from a sanitary standpoint; but with regard to animal life in our rivers, sewage does not seem to be harmful; on the contrary, certain forms (fishes, crawfishes, mussels) seem to thrive on it. Only in a few cases I have seen sewage so concentrated (certain small runs in the city of Pittsburgh), that animal life is killed.

Much more dangerous sources of pollution are given by our *coal mines*. Under this head I unite all sources of pollution, which are connected with the mining of coal, with the coking process, and with the steel industry. This kind of pollution is very widely distributed in the western part of the state. It is a process which charges the water of our streams with certain acids, which, when they reach a certain degree of concentration, directly kill the life.² A stream polluted by "mine water" is easily recognized (when clear) by the peculiar bluish-green color of the water, and by a peculiar rusty-red deposit upon its bottom.

Another source of pollution is furnished by the *oil wells* and the oil industries. The simple working of an oil well already yields injurious matter: during the drilling of the well invariably *salt water* is pumped up, and the *oil* itself is capable of destroying life, if present in excess, and forming, at low stages, a deposit upon the

² See Stabler H., Water Supply and Irrigation Paper no. 186, 1906, p. 5.

bottom of a creek. But the worst are the *oil refineries*, which discharge into the water chemicals which are utterly destructive to life.

These are the two most important sources of the pollution of our streams: *coal* and *oil*. In addition, there are others, which are more or less local, yet may become quite important in certain sections. These are various industrial establishments, such as *glass factories*, *china factories*, different kinds of *chemical factories*, *wood-pulp mills*,³ *saw mills*, *tanneries*, etc. There are certain sections of the state, for instance the region of the headwaters of the Allegheny and of Clarion River, where establishments of this kind are the chief source of contamination.

It is not my intention here to treat of the chemical side of the process, because it is rather complex, and needs careful investigation by experts. This investigation is rendered more difficult, since in most of our streams it is not one cause, which contributes to the pollution, but several, often all of them, which contribute their share in a particular stream.

Finally, a last cause of destruction of life should be mentioned, which, however, is not connected with a deterioration of the quality of the water. This is the *damming up of certain rivers*. This has been done most extensively in the Monongahela River, and in a part of the Ohio below Pittsburgh. The dams and locks have been built for the advantage of the shipping interests, producing a more uniform level of the water, permitting navigation all the year round. By this process the rivers, which originally possessed a lively current, with riffles, islands, etc., have been transformed into a series of pools of quiet, stagnant water, and this change has driven out certain forms of life. It is most destructive to mussels, most of which require a lively current. Dams also prevent free migration, for instance of fishes, and thus they must be an obstacle to the natural restocking of the rivers in periods of high water.

³ See Phelps, E. B., Water Supply and Irrigation Paper no. 226. 1909.

III. SKETCH OF THE PRESENT CONDITION OF OUR RIVERS.

(See map, plate VI.)

I. *The Ohio River Below Pittsburgh.*

At Pittsburgh, the two main rivers, *Allegheny* and *Monongahela*, unite to form the *Ohio*. As we shall see below, both the *Allegheny* and *Monongahela* are as badly polluted as they possibly could be, and, consequently, it is not astonishing that the *Ohio* immediately below Pittsburgh is also in a deplorable condition. In addition, it is dammed up, this "improvement" extending down to dam No. 6 at Vanport (below Beaver) in Beaver County. Generally, there is not much life in this part of the Ohio. Fishes are found occasionally, during high water, due to some migration, probably from farther down the river, but even this has been rendered difficult or even impossible in consequence of the perfection of the dams (dam No. 6 was finished and put in operation toward the end of 1907). There are crawfishes in this part of the river, but they are disappearing fast. Unionidæ have disappeared long ago. There was a colony of them in the left branch of the Ohio at Neville Island, Allegheny County, up to 1904; during that year, however, they died out, and in 1905 the last living one was found there.

Farther down, below dam No. 6, conditions improve. This is a very interesting and important fact. Although the Ohio collects most of the polluted water of the western section of the state, and although it is in a very bad condition below Pittsburgh, it loses its bad qualities, at least in part, about thirty miles farther down. Since there are only two important tributaries along this part of its course, Chartiers Creek and Beaver River, both of them also badly polluted, this improvement of the water cannot be due to dilution alone, but it is evident that some of the injurious substances in the water must be removed from it, and very probably by precipitation upon the bottom of the river. We shall observe indications of this process elsewhere, and shall discuss its significance below. Here it is sufficient to point out, that at present (1908) the condition of the Ohio below dam No. 6 is good or fair, life being not only possible, but abundant in it, all the way down to the state line at Smith's

Ferry. This is shown first of all by the abundance of Unionidæ in this part of the Ohio; in fact, here are found the most favorable localities for them known to me in western Pennsylvania. It seems that in 1907 these conditions extended a certain distance farther up; at any rate, in that year I found evidence of the presence of Unionidæ in the Ohio at Beaver (the stage of the water was not low enough for proper investigation). But since the completion of dam No. 6 this is all over now, and if there should be life in the pool above dam No. 6 it will have disappeared by this time, at least most of it.

Moreover, there are indications that the fauna in the Ohio below Vanport is already suffering. There are at least two tremendous banks, consisting chiefly of dead shells (with many living ones among them) in the river, one at Industry, the other at Shippingport. Since dead shells are dissolved rather rapidly, these masses indicate a recent dying of mussels on a large scale. And further, it is very remarkable that among the living shells collected by myself there are hardly any young individuals. It seems to me that, while the old and tough ones (some of them probably ten years old and older) are able to stand the poor condition of the water, the latter is too much for young and delicate ones, so that there is no new generation growing up. This, of course, would be the first step toward the final destruction of the mussels in this part of the river, and the destruction of the other forms of life then will also be accomplished in due time.

2. *The Smaller Tributaries of the Ohio.*

There is a group of streams in Greene and Washington Counties, running westward through the panhandle of West Virginia into the Ohio. These are (from south to north): *Pennsylvania Fork of Fish Creek, Wheeling Creek, Buffalo Creek, Cross Creek, Harmons Creek*. They are all clear creeks, only *Harmons Creek* and *Cross Creek* are slightly polluted by mine water, but not much damage has been done yet. They are all rich in aquatic life. I have not visited *Wheeling Creek* in Pennsylvania, but I know it in West Virginia, above Elm Grove, near Wheeling, where it is in good condition.

Raccoon Creek, which empties from the south into the Ohio

below Vanport, is in very good condition for most of its length, only way up at its sources, in Washington County, it is slightly polluted by mine water. This creek used to be rich in all forms of life, and is yet so here and there, but, as has been said, its fish fauna has greatly suffered in consequence of illegal fishing.

At the point where the Ohio leaves the state a very beautiful tributary flows into it from the north—*Little Beaver Creek*. This was, and partly is, a model stream with regard to all forms of fresh-water life. Yet in 1908 there were, in its upper parts, near New Galilee, in Beaver County, signs of pollution, in this case in consequence of new oil wells being drilled in the vicinity. Salt water and oil was discharged into the creek, and the fauna (chiefly the mussels) indicated distinctly the deteriorating effect by their diseased condition and by the frequency of shells which had died recently. This may be only a temporary effect, and if there is no additional pollution, conditions may remain favorable.

Immediately below Pittsburgh, *Chartiers Creek*, coming from the south, empties into the Ohio. It is hopelessly polluted by the coal mines and oil refineries in Allegheny and Washington Counties. There is no life whatever in this creek: the last traces are known to have existed in it as late as 1900, when a few Unionidæ were collected in it for the Carnegie Museum. The condition of Chartiers Creek is now beyond repair.

3. *The Beaver River Drainage.*

Beaver River flows into the Ohio from the north at Beaver, Beaver County. It is utterly polluted in its whole length, up to the point where it is formed by the confluence of Mahoning and Shenango rivers. The source of the pollution is situated on the Shenango River, along its last two miles, in and below Newcastle, Lawrence County. The steel mills and various other establishments furnish a tremendous amount of injurious refuse draining into the river, and rendering it entirely unfit for life. This state of affairs has been brought about during the last ten years, for in 1898 the fauna of the river was very rich at Wampum, Lawrence County, as is shown by collections preserved in the Carnegie Museum.

Connoquenessing Creek, flowing into the Beaver from the east, is another badly polluted stream. In this case there are various causes of pollution, but the chief one is the refuse from the glass works at Butler, Butler County. In the lower parts of Connoquenessing Creek traces of life are yet present, but in a few years everything will be gone. Above Butler, the creek is in a fair condition. Of its tributaries, *Glade Run* is polluted by oil well products. *Brush Creek* is good, and also *Slipperyrock Creek* in its lower course. The latter is an example of the natural clearing of the water, for in its upper parts, in northern Butler County, it is in a very bad condition, polluted by mine water. In this case dilution of the pollution apparently plays an important part, for at least two of its tributaries, *Wolf* and *Muddy Creeks*, are in good condition. In *Wolf Creek* the effect of plain sewage is distinctly seen by the fact that the fish- and mussel-fauna are favored by it—the Unionidæ attain an unusual size just below the point where the sewage from Grove City, Mercer County, goes into the creek.

Of the two rivers which form the Beaver, *Mahoning River* is, as has been shown by Leighton,⁴ badly polluted in the state of Ohio at Alliance, Warren, Niles and Youngstown. Yet in Pennsylvania, in its lower parts, it is rich in life. We again have to deal here with the natural clearing process of the water. At Hillsville, where the Mahoning enters our state, it is in poor condition, yet there is some life. Then comes a dam at Edinburg, and below this dam conditions are much better. In fact, the fauna is rich, and continues so till the river joins the Shenango. In this case, there are no important tributaries along this stretch, and the clearing of the water cannot very well be attributed to dilution.

The *Shenango River* above Newcastle is in good condition all the way up to its sources, and so are its tributaries, *Neshannock Creek*, *Pymatuning Creek* and *Little Shenango River*. Only at and below Sharon and Sharpsville, in Mercer County, some pollution goes into the Shenango from the steel mills, but it has not had much effect yet. However, the damage is bound to increase, and I am afraid in a few years the effect will be noticeable. At the present

⁴See Leighton, M. O., U. S. Geol. Surv. Water Supply and Irrigation Paper no. 79, 1903, p. 133.

time these creeks are in splendid condition at many points, and this is preëminently the case, as regards the fish fauna, in Neshannock Creek.

4. *The Monongahela Drainage.*

We may say that of the Monongahela drainage by far the greatest part is utterly polluted, chiefly by mine water.⁵ The *Monongahela* and its chief tributary, the *Youghiogheny*, drain the most important coal regions of the state, and there are, in this whole region, only a few streams left which have clear water. They are the following: *Ten Mile Creek* and *Dunkard Creek* in Washington and Greene Counties, yet the *South Branch of Ten Mile Creek* became polluted in the spring of 1908 by the bursting of an oil pipeline near Waynesburg, Greene County. *Dunkard Creek* is yet splendid in every respect. *Cheat River* is clear, but there are only two or three miles of it in the state, and on its right banks, at Cheat Haven, a small run empties into it, which brings a great amount of mine water from the coke-ovens at Atchinson, killing everything along its right banks.⁶

The *Youghiogheny* is in a fair condition above Connelsville, Fayette County, and *Indian Creek*, one of its tributaries, is very good (trout stream). However, the *Youghiogheny* has improved from Confluence down. For at this place it receives a badly polluted tributary, *Casselman River*, which brings mine water from the mines in southern Somerset County. The *Youghiogheny* above Confluence, south into Maryland, is very clear and pure.

For the rest, all the more important creeks tributary to the Monongahela system, in Washington, Fayette and Westmoreland Counties, are polluted by mine water. This is especially true in the cases of *George* and *Redstone Creeks*, draining the Uniontown district, *Jacobs Creek*, coming from the Mount Pleasant and Scottdale mines, and, worst of all, *Turtle Creek*, with its tributary, *Brush Creek*, which drain the coal fields of Westmoreland County.

⁵ Leighton, *ibid.*, p. 126 ff. This condition obtained already in 1898, see Rhoads, S. N., in *Nautilus*, 12, 1899, p. 133.

⁶ The condition of the Cheat below Parsons, Tucker Co., W. Va., is dreadful, it being polluted by the refuse from a wood pulp mill. But it improves farther down.

5. *The Allegheny Drainage.*

(a) *The lower Allegheny, from Oil City and Franklin (Venango County) downward*, is first badly polluted, then it improves, and is again polluted to a very considerable degree. The chief source of pollution are the oil refineries at Oil City and Franklin. The injurious substances discharged into the river at these two places are simply amazing, and render the river entirely unfit for life; for thirty miles and more below there is not a mussel, not a crawfish, nor a fish able to live in this water. Then a gradual improvement begins in southern Venango County (pond snails, *Physa* and *Goniobasis* are present, also crawfishes begin to appear), and in northern Armstrong County conditions become almost normal. In spite of some additional pollution going into the river at Kittanning and Ford City (china factories), the good condition continues down to the point where the *Kiskiminetas River* discharges its mine water into the Allegheny from the left side. This destroys life on the left banks of the Allegheny, but conditions continue favorable on the right banks into Allegheny County, till we reach Natrona and Tarentum. Here additional pollution comes in in the shape of salt water (salt works at Natrona) and the refuse of various mills, and this goes on all along the river down to where it unites with the Monongahela at Pittsburgh. Here the Allegheny is utterly polluted, and we have here possibly the greatest variety of pollution of any of the streams in the state.⁷

(b) *The Smaller Tributaries of the Lower Allegheny River.*—Of the following smaller tributaries of the lower Allegheny, the condition is known to the writer. On the right side, *Pine Creek*, in Allegheny County, is polluted more or less, chiefly by oil wells, but its headwaters are in a fair condition. *Deer Creek* and *Bull Creek* are rather good. *Buffalo Creek*, running along the boundary line of Butler and Armstrong Counties, is in very good condition, and contains an abundance of life. On the left side is *Puketta Creek*, forming the boundary of Allegheny and Westmoreland Counties, which also is in rather good condition.

(c) *The Kiskiminetas Drainage.*—As has been stated above, the

⁷ See Leighton, M. O., l. c., p. 122.

Kiskiminetas River, at its point of union with the Allegheny, is in a fearful condition, the pollution consisting chiefly of mine water from the extensive coal regions of Westmoreland, Indiana, Cambria and Somerset Counties. In fact, we may say, that in almost all of the drainage basin of the *Kiskiminetas* fresh-water life is extinct.⁸ For the main stream, the *Kiskiminetas-Conemaugh*, this is true for its whole length, from above Johnstown in Cambria County downward. The *Loyalhanna River* from Latrobe downward is even worse than the *Conemaugh*. *Black Lick Creek* and its tributaries, *Two Lick* and *Yellow Creeks*, in Indiana County, are also polluted, and so is *Stony Creek* in Somerset County. There are, in the whole *Kiskiminetas* drainage, only very few streams possessing clear water and a tolerably well preserved fauna. In Westmoreland County we have a small stream, *Beaver Run*, which is good, and the *Loyalhanna River* above Latrobe contains a rich fauna. In Indiana County *Blacklegs Run* and the upper parts of *Two Lick* and *Yellow Creeks* are in good condition; in the lower part of *Yellow Creek* the fauna was destroyed during 1908. A mine had been opened in 1907 above Homer City, and the mine water discharged into the creek did its deadly work in the summer of 1908, when the stage of the water for the first time after the opening of the mine became so low that the concentration of the pollution was great enough to kill the fauna. On July 23, 1908, the writer personally witnessed the actual destruction of the fauna, and the number of dead and dying fishes seen in *Yellow Creek* at Homer City was perfectly appalling.

Clear tributaries of the *Conemaugh* are found in the valley between Chestnut Ridge and Laurel Hill: *Tub Mill Run*, for instance, near New Florence, is very good (trout stream). As has been said, *Stony Creek*, in Somerset County, is polluted. Of its tributaries, at least one is in good condition: *Quemahoning Creek*; others have not been investigated, but probably there are more clear streams, chiefly among the headwaters coming down from Laurel Hill and Allegheny Front.

(d) *The Great Eastern Tributaries of the Allegheny*.—There are

⁸ This is very deplorable in view of the fact that for several fresh species, described by Professor Cope, the *Kiskiminetas* is the type-locality. No topotypes can be secured any more.

a number of important tributaries, running about parallel to each other from the east to the west into the Allegheny. These are (from south to north): *Crooked Creek*, *Mahoning Creek*,⁹ *Red Bank-Sandy Lick Creek* and *Clarion River*. *Crooked Creek* is good, indeed, one of the best creeks in the state, yet in the region of its headwaters pollution begins. Near Creekside, Indiana County, new mines have been opened during the last years, and a small tributary discharges here a considerable amount of mine water into Crooked Creek, killing the fauna for several miles. Of course this is bound to become worse in the future. *Mahoning Creek* is utterly polluted, the pollution beginning in the region of Punxsutawney in Jefferson County, and consisting chiefly of mine water. Yet a tributary, *Little Mahoning Creek* in northern Indiana County, has clear water, and correspondingly a rich fauna. *Red Bank-Sandy Lick Creek* also is polluted, chiefly by mine water, which reaches it from the numerous mines existing in its drainage basin. *Clarion River* possibly is one of the worst streams in the state. In the region of its headwaters, in Elk County, it is not mine water, but the refuse of various establishments, such as wood-pulp mills, tanneries, chemical factories (*Elk Creek*), which renders the water unfit for life, and finally *Toby Creek*, emptying into it in the southwestern portion of Elk County, adds its share in the form of mine water. The water of Clarion River, in this region, is black like ink, and retains its peculiar color all the way down to where it empties into the Allegheny (at Foxburg); here the deep blackish brown color of the Clarion River water contrasts sharply with the bluish green water of the Allegheny River.

(e) *French Creek Drainage*.—In contrast to most of the streams mentioned so far, *French Creek* and its tributaries are generally clear and possess a wonderfully rich fauna. In fact, this region is one of the best collecting grounds for all forms of fresh-water life. French Creek is fed by several streams draining some of our glacial lakes—*Conneaut Lake* in Crawford County, and *Conneauttee Lake* and *Lake Lebauf* in Erie County. Also these have clear water and a rich fauna.

(f) *The Upper Allegheny*.—Above Oil City, Venango County,

⁹ Not to be confounded with Mahoning River in Lawrence County.

the *Allegheny* itself is clear, and also forms a fine collecting ground for the zoölogist. This is especially true for the fish fauna and the fauna of fresh-water mollusks. This good condition continues up to the New York state line in Warren County. Of the tributaries, *Oil Creek* is badly polluted at Oil City, where it falls into the *Allegheny*, but it is pure at its headwaters. The intermediate parts have not been studied by the writer, so that he cannot name the exact spot where the pollution begins. It is due chiefly to oil refineries. *Tionesta Creek*, in Forest County, is polluted by chemical refuse, at least where it enters the *Allegheny*; the upper parts have not been investigated. *Brokenstraw Creek*, in Warren County, is in a fair condition, but it belongs to the class of streams which improve during their course: its headwaters are polluted by refuse from tanneries at Cory in Erie County. *Connewango Creek*, in Warren County, which brings the outflow of Chautauqua Lake in New York, is good. The headwaters of the *Allegheny* in McKean and Potter Counties are generally good, but there are some tributaries which are polluted, for instance, *Potato Creek*, in McKean County (polluted by chemical factories). Where *Potato Creek* falls into the *Allegheny* it is in a very bad condition, but its size is not sufficient to influence the *Allegheny* noticeably.

6. *The Lake Erie Drainage.*

Of course *Lake Erie* itself is clear, and contains a rich fauna.¹⁰ In our state there are rather insignificant streams draining into the lake, and they all have pure water, and, as far as they have been examined, a well-preserved fauna. The largest is *Conneaut Creek*, in Crawford and Erie Counties, which has been investigated at several places by the writer, and found to be in good condition. The only other streams known to the writer are *Elk* and *Walnut Creeks*, in Erie County, which are also good.

7. *The Potomac and Susquehanna Drainages.*

Only the headwaters of these streams or their tributaries are situated in western Pennsylvania, and the investigations of the writer are not very extensive in this region.

¹⁰ Our knowledge of the Lake Erie fauna is deplorably poor, chiefly so with reference to the Pennsylvania shores.

Wills Creek, in southern Bedford County, flowing to the Potomac is clear, but it becomes polluted by mine water farther down, at Mt. Savage Junction in Maryland.¹¹ Several of the headwaters of the *Juniata River*, in Blair County, chiefly in the region of Altoona and Tyrone, are polluted by industrial establishments.¹² The headwaters of the *West Branch of the Susquehanna* and *Clearfield Creek*, in Cambria and Clearfield Counties, are generally polluted by mine water,¹³ but there are some clear tributaries. A rather good one is *Cush-Cushion Creek*, in Indiana County. The latter fact is very important, for it is the point of the Susquehanna system which is most advanced in a westerly direction, and marks the most western extension of the Atlantic fresh-water fauna in our state, and it may be said here that Cush-Cushion Creek indeed contains a pure Atlantic fauna, which is in sharp contrast to the western fauna present in some of the tributaries of the Allegheny in the same (Indiana) county, Little Mahoning, Crooked, Two Lick and Yellow Creeks.

CONCLUSIONS.

The sketch given above of the present condition of our streams and their fauna is sufficient to give an idea of the tremendous damage done in recent times to our fresh-water fauna. Considering the fact that most of this destruction has been accomplished during the last twenty years; that it is going on continually, and that every year new stretches of the rivers, new creeks are added to the list of the polluted waters, conditions are indeed alarming. I think a glance upon the map accompanying this paper will tell more than any words possibly could.

It is not for the writer to suggest remedies, yet two conclusions are forced upon him. The first is, that with regard to the improvement of the fish-fauna, which is attempted by the State Fish Commis-

¹¹ See Parker, H. N., Water Supply and Irrigation Paper no. 192, 1907, p. 219.

¹² The quality of the water was poor already in 1904, see Leighton, M. O., in Water Supply and Irrigation Paper no. 108, 1904, p. 65.

¹³ Leighton (*ibid.*, pp. 56 and 57) gives in 1904 a rather favorable report on the quality of the headwaters of the West Branch of the Susquehanna (chiefly with regard to drinking purposes). Apparently this has changed to the worse during the last four years.

sion by way of restocking our rivers with game and food fishes, this is a useless undertaking in all those streams which are polluted. Any fishes set free in such waters will not live, or will not stay there, if they can. The other suggestion is furnished by the fact, repeatedly mentioned above, that a river, badly polluted at a certain point, improves in its further course, provided no additional pollution in great quantities is reaching it.¹⁴ This is seen first of all in the Ohio itself in Beaver County, and further in the Allegheny in Armstrong County. Additional examples are Slipperyrock Creek, Mahoning River (Lawrence County), Raccoon Creek, Brokenstraw Creek, Cheat River. This improvement of the waters, of course, is partly due to the dilution of the injurious substances by the addition of clear water from tributaries. But it seems as if this is not the only source of the improvement. In the case of the Allegheny in Armstrong County, the main tributaries (Clarion, Red Bank, Mahoning) themselves are polluted, and the other tributaries are very insignificant in comparison with the size of the Allegheny. This is also seen in the Mahoning River in Lawrence County, which hardly has any tributaries along its course, where the improvement takes place. I think the precipitation of the injurious substances to the bottom plays an important part here. We always have, in polluted streams, some sort of precipitate upon the bottom, most noticeable in streams charged with mine water, where it consists of sulphate of iron,¹⁵ and, consequently, the injurious element must be eliminated, at least to some degree, from the water. This observation suggests a natural remedy—if we could prevent the water charged with polluting substances from reaching our streams directly, that is to say, if we could arrange it that this water is kept in basins or reservoirs for some time, till it has gone through this natural clearing process, and if we allowed only the overflow of these clearing basins to reach our rivers, that is to say, the most superficial strata, which contain the smallest amount of polluting substances,¹⁶ I think this

¹⁴ See Stabler, Water Supply and Irrigation Paper no. 186, 1906, p. 28.

¹⁵ See Leighton, *l. c.*, p. 24.

¹⁶ Of course, the oil from the oil wells floats on the surface, but this floating oil does not do much damage. It is well known that before the discovery of oil in these parts, the Allegheny was famous for the oil floating upon its surface.

would improve conditions considerably. The presence of dams in our rivers or creeks furnishes, to a certain degree, the conditions required for such clearing basins, and we have observed instances (Mahoning River at Edinburg, Lawrence County), where such a dam actually improves the river to a considerable degree. This is also the case, although not so strikingly, with dam No. 6 in the Ohio River. But the trouble is these dams improve the water after much damage has been done already, and are injurious in other respects (see above).

This much, however, should be clear—unless we improve the quality of the water of our rivers, it is impossible to bring back the original condition of their fauna, and attempts to restore our natural resources with regard to the fish fauna, by restocking our polluted streams with fish, will be labor and money thrown away.

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